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Analysis of a PV Window for Building Integrated Photovoltaic (BIPV) Applications

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Introduction

The buildings are currently high-energy consumers contributing largely to climate change.

The solution to the climate crisis will involve many facets, but it must involve reducing greenhouse gas emissions and other sources that have a climate-changing impact.

Integration of energy renewable systems in building is presented as an important tool to reduce pollutant emissions.

Introduction

The use of Building Integrated Photovoltaic (BIPV) systems may contribute to achieve this goal.

The integration of solar modules in the enclosures not only provides great economic saving and avoids emissions of pollutants but also has thermal insulation properties making these buildings more efficient.

Another positive aspect is that the use of this technology avoids altering the aesthetics of the buildings where they are integrated.

Objectives

- To obtain the unknown characteristic parameters of a PV window.
- To obtain the energy production.
- To analyze the installation of this window in the skylight of the Industrial Engineering School of Málaga.
- To study the economic and environmental feasibility of the installation.

Window PV characteristics

Amorphous silicon photovoltaic cells encapsulated between two transparent glass sheets, an air chamber and a second double glass sheet with an air chamber form the photovoltaic window.
The effective dimensions of the a-Si photovoltaic module are 0,57x1,17 m^2, equivalent to a standard measurement of 0,60x1,20 m^2.
The frame of the window made with PVC is in charge of putting the structure together.

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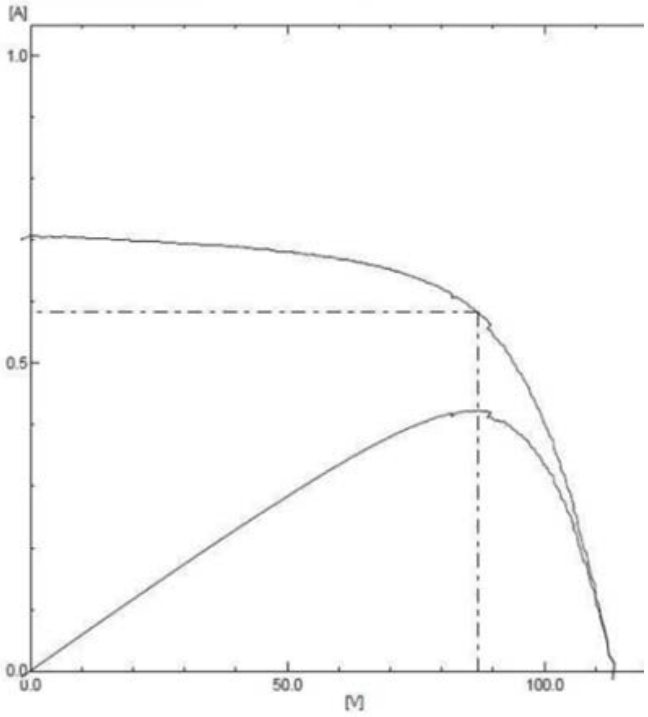
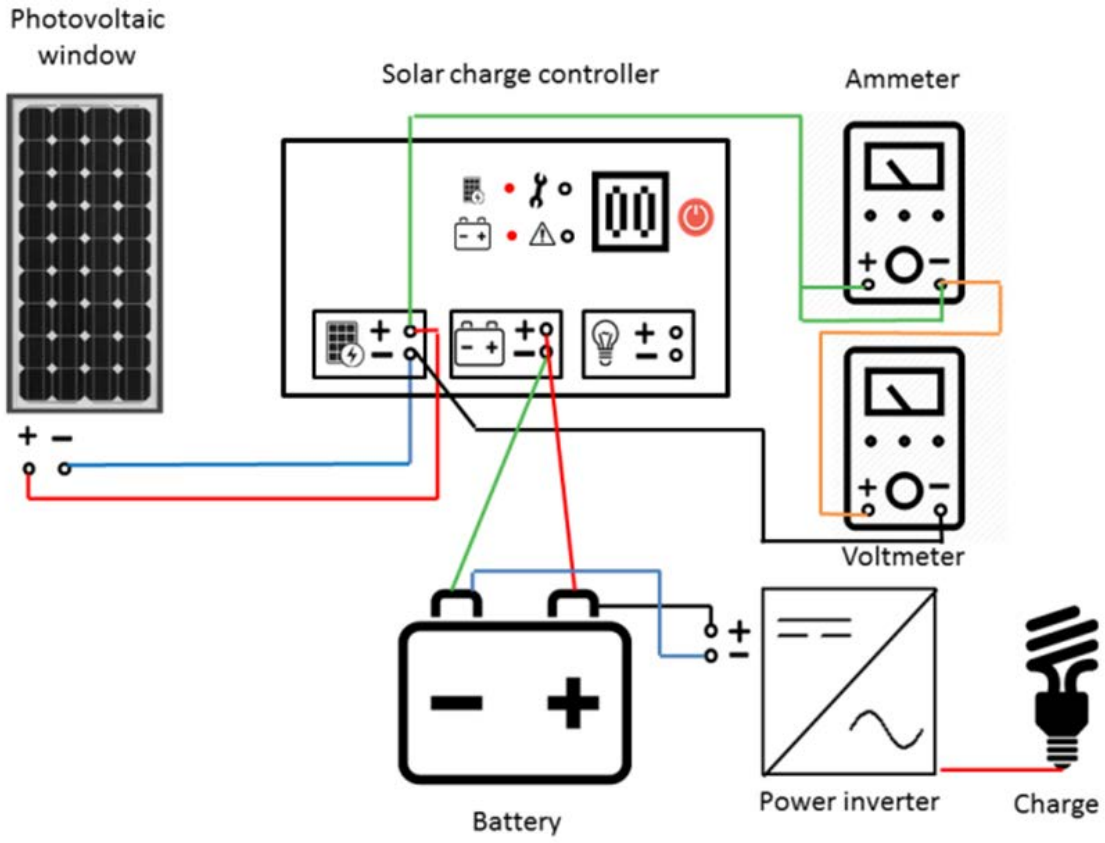
Window PV characteristics

To determine the electrical characteristics of the photovoltaic window under the standard conditions of measurement, a test was carried out according to IEC



T_{max}(ºC)	23,3
T_{min}(ºC)	21,3
RH_{max} (%)	54,3
RH_{min} (%)	51,1
RH_{limit} (%)	<70
I_{sc} (A)	0,71
V_{oc} (V)	113,19
V_{max} (V)	87,18
I_{max} (A)	0,58
Peak power (W_p)	50,74

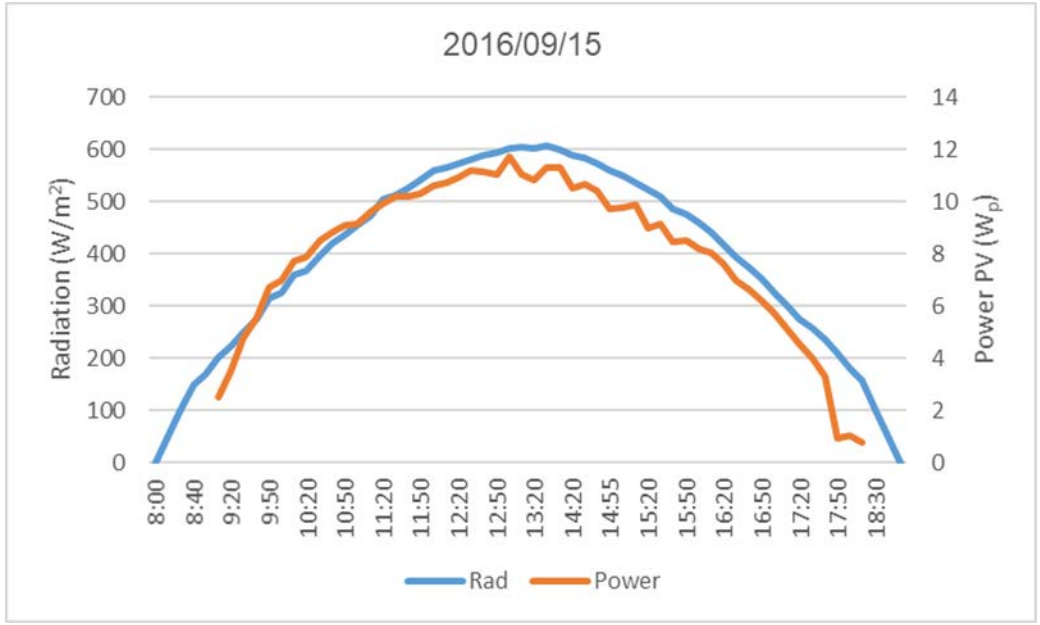
Energy production



Energy production

Irradiance received on the plane of the photovoltaic window at daytime: 4114 Wh/m^2

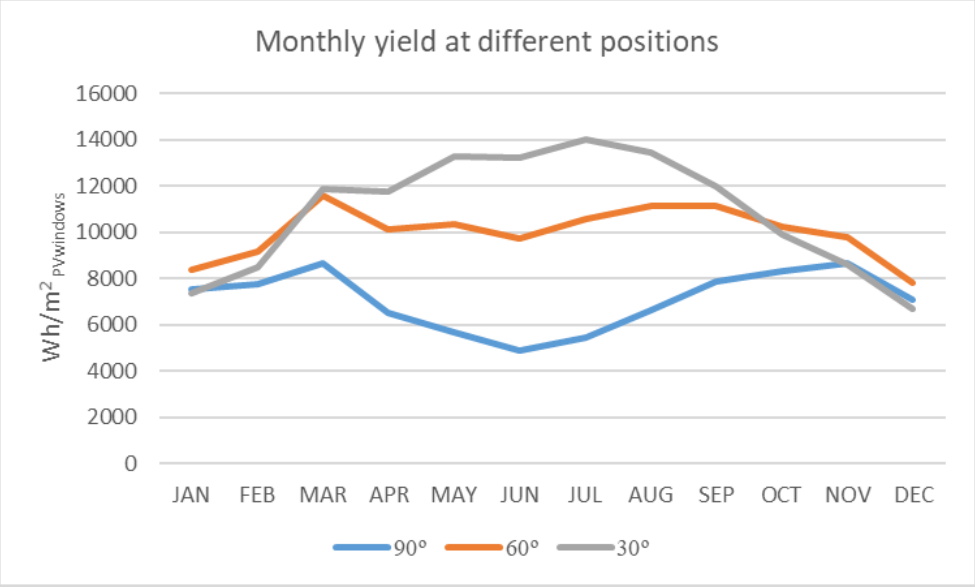
Energy produced: 71,2 Wh.



These values are consistent with radiation data obtained from databases and the power value obtained from PV window under standard test conditions.

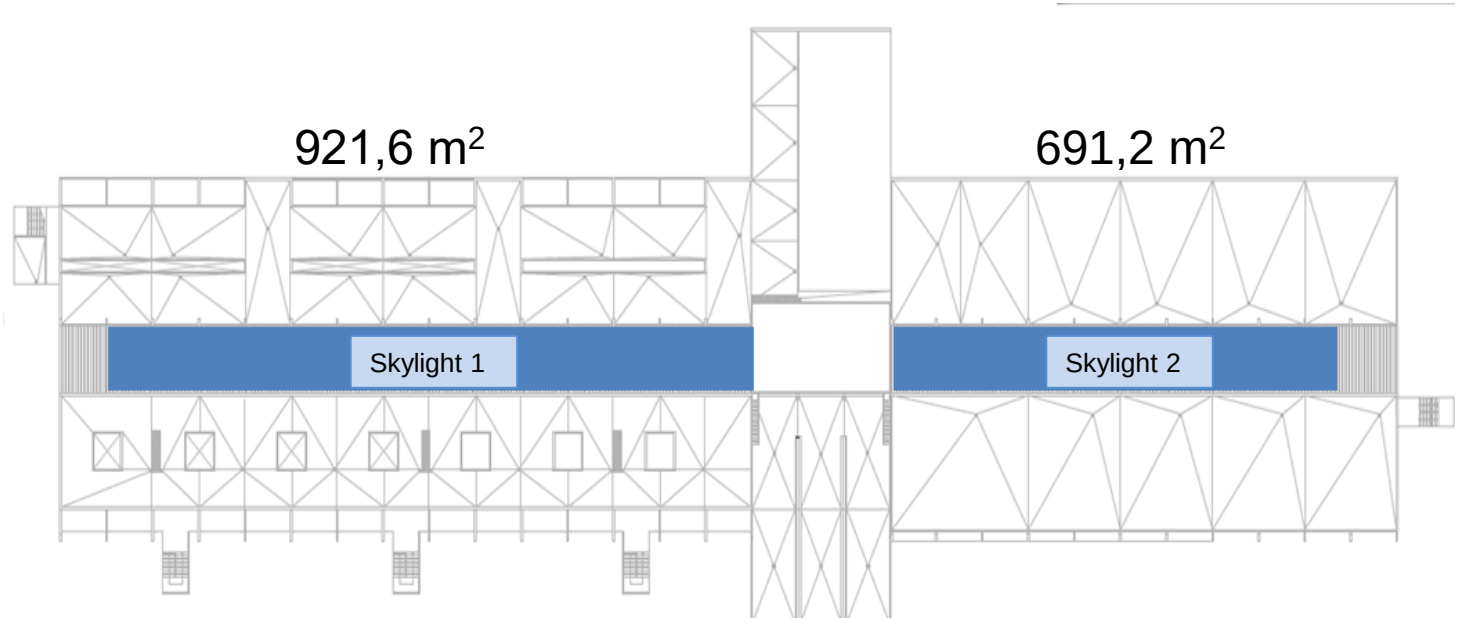
Energy production

The annual production can be improved if instead of using the photovoltaic module as a vertical window, the same semi-transparent photovoltaic module is used as an enclosure element in a building.



Case study

The integration of photovoltaic windows in building enclosures has many advantages over conventional systems: reduction of energy consumption, economic savings, and environmental benefits such as the reduction of CO_2 emissions.



Total PV surface: 1612,8 m^2

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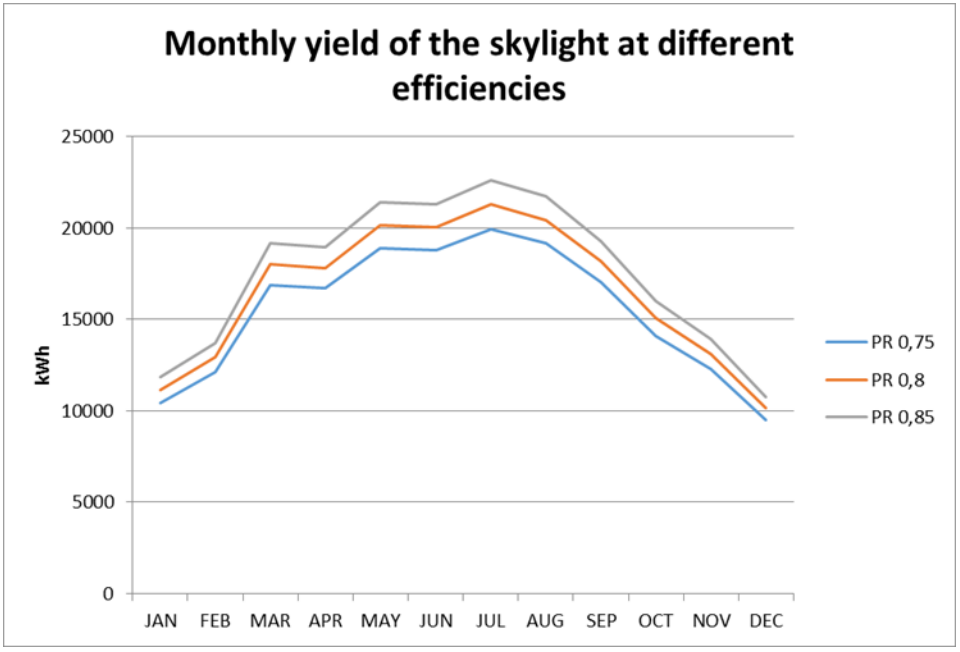
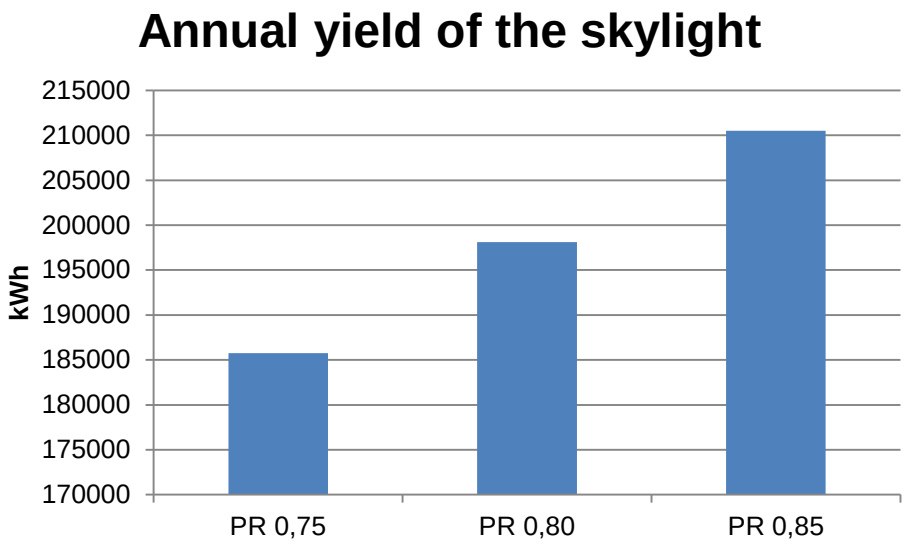
Case study





Case study

Economic study

Initial investment: 379630,91€
Daily average price of energy, taxes included: 0,199 €/kWh

Efficiency	0,75	0,80	0,85
Annual savings (€)	26004	27738	29471

Using the "payback" method the return of the investment is 12 years.

The internal rate of return method obtained a IRR value of 3%.

This indicates that it would be a risk investment since the optimal value for an investment without risk is 10%.

Case study

Savings in CO_2 emissions

Eff	T of CO_2 savings per kWh
0,75	71,51
0,8	76,28
0,85	81,05

Tonnes of oil equivalent (TOE)

Eff	TOE
0,75	15,97
0,8	17,04
0,85	18,10

Conclusions

- A photovoltaic window to be used as a BIPV application have been analyzed.
- The peak power at standard test conditions was 50,74 Wp.
- When placing PV window in vertical position 71,2 Wh of electric energy is obtained if a radiation of 4114 W/m^2 in a day reach the window plane facing south.
- The tilt angle affects the yearly energy production of the PV window. The bigger production correspond to a tilt of 30º.
- Integrating the semi-transparent PV windows in the skylight of the Industrial Engineering School of Malaga allows
  - A PV facility of 122 kW_p that would produce a yearly average electric energy of 198125 kWh.
  - A money average saving of € 27738
  - A risky investment because the 3% of IRR obtained
  - 76 tons of CO_2 into the atmosphere would be avoided that represent 16,98 toe

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Thank you for your attention

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